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A MONOGRAPH ON LAND-PLANARIANS.

Monographie der Turbellarien. II. Tricladida Terricola (Landplanarien). By Prof. Ludwig von Graff. Pp. i + 574, and an atlas of 58 plates. (Leipzig: W. Engelmann, 1899.)

THE Turbellaria are rapidly becoming one of the most adequately and conveniently described groups of Invertebrates. Practically all that is at present known as to their anatomy, classification and distribution is comprised in three works—the “Monograph,” by Prof. von Graff; the special memoir, by the same author, on the “Acœla”; and the masterly work, by Prof. Arnold Lang, on the “Polycladida” in the series of monographs on the fauna and flora of Naples Bay. The work before us, a magnificent folio, completes the author’s share in the monographic treatment of the group. The first part was published in 1882, and was reviewed in this journal by Prof. Moseley. It is with great pleasure that we notice the dedication of the second part—jointly to Moseley and Fritz Müller—as only one of the many felicitous ways in which Prof. von Graff expresses his admiration for the work of these his fellow-labourers in the anatomy of planarians. We heartily congratulate Prof. von Graff on the appearance of this volume, the conclusion of a work begun twenty-five years ago.

Apart from all other claims upon our notice, this treatise is remarkable as being the first attempt to deal exhaustively with an essentially tropical group of animals, for nothing can be clearer, after reading this account, than that land-planarians, though not restricted to the tropics, have their headquarters in the equatorial forest belt. Von Graff has himself spent some time in Java, Singapore and Ceylon, and the personal acquaintance made in this way with these animals, and the conditions under which they live, gives a vividness and directness to his descriptions. Other naturalists have notably assisted him. Prof. Dendy, whose admirable and continued researches on the land-planarians of Australia and New Zealand receive full acknowledgment in this work, Spencer, Hamilton, Fletcher and others have sent collections of these animals to von Graff from Australia. Strübell, Max Weber, the Sarasins and others have contributed specimens collected by them in the Oriental region. South America is represented by planarians taken by Darwin, Fritz Müller, von Jhering and Plate. Nearly all the chief museums in Europe have contributed their specimens to von Graff, and in this manner he has been able, not only to more than double the number of species which were recognised when he began this work, but also to personally examine all but a very small percentage. To realise the rapidity of the increase in species of land-planarians during the last twenty years, it will be sufficient to state that Moseley’s complete list, made in 1877, comprised only 63 forms, while 125 were known when von Graff began his monograph on the group, during the course of which he has added no less than 200 new species, and this, together with increments from other sources, makes a total of 348.

Of this unexpectedly large number (for it is about equal

to all the other Turbellaria put together which have been really adequately described), less than a dozen occur (with the exception of the Manchurian sub-region) in both the Palæartic and Nearctic regions. The majority come from South America, the Oriental and Australian regions. Even this statement, however, does not represent the richness of the tropics, for Australia is really the only country where land-planarians have been systematically collected and recorded. Our knowledge of the planarian fauna of Africa, India, China, Central and North America is almost a blank. And additions to it will no doubt be made, not only in these countries, but also in places in which naturalists have already sought planarians. The island of Celebes, for example, has been examined by several zoologists, who have searched for land-planarians, but without success. Hickson, and after him Max Weber, searched in vain. More recently, however, the Sarasins have thoroughly explored the island, and have brought to light a most interesting fauna. Von Graff shows that the land-planarians of North Celebes exhibit Oriental characters, those of South Celebes Austro-Malayan features. Altogether twenty-one Celebesian species are now known, and of these all but three are new. We refer to this point particularly as showing that we are only beginning to realise the variety of this element of the tropical fauna, and that years of work are necessary in any one country before the planarian fauna can be fairly estimated. In Ireland a new species has been found near Dublin, and two other additions to the land-planarians of Europe have been made quite recently.

The first part of von Graff’s great work is devoted to a full statement of the anatomy and histology of land-planarians. This section must have involved a vast expenditure of labour. Direct observation of the anatomy of living or compressed specimens is impossible, owing to the amount of opaque pigment in the tissues. Even the external apertures are hard to discover. Dissection is precluded by the solidity and tenuity of the body. The only available means in the majority of cases is the laborious one of serial sections, and this method the author has applied to elucidate the structure of no less than eighty-two species.

The chief result obtained in this way is the uniformity of the general anatomical features. Land-planarians form a homogeneous group, and agree closely in structure with the marine Triclad Turbellaria so far as these are at present known. Their distinguishing features appear to be correlated with the terrestrial habit. Among these may be mentioned their greater size and more powerful musculature; the formation of a “keel” to the foot, and the abundance of glands both for lubricating the foot and for enveloping prey; their brilliant, often intensely brilliant, colouring; the presence of sensory thickenings and of sensory pits on the anterior part of the body; and, perhaps their most significant distinction, the presence of elaborate structures accessory to reproduction. The anatomy of some of the simpler land-planarians is, however, an almost exact repetition of an aquatic Triclad, and the retention of cilia in the epidermis points to the conclusion that in land-planarians we have the first stage in the evolution of a terrestrial group from an aquatic one.

The presence of three extreme forms of rod-like secretions and the absence of nematocysts are noteworthy features of the epidermal glands. "Flame-cells" and parts of the canalicular system of excretory vessels have been found. The nervous system exhibits an interesting series of modifications. In the most primitive members of the group—the broad, flattened neotropical Geoplanidæ—the central nervous system consists of a dense plexus forming a horizontal plate lying just above the ventral body-wall. From this plexus nerves are given off, which either at once enter some organ or join with their fellows to form a well-developed cutaneous nerve-plexus right round the body. There is no distinct "brain." In the narrower neotropical and Australian members of the same family, a concentration of this central plexus takes place along two admedian lines, and a marked anterior thickening indicates the "brain." In the other families, as the sense-organs, which are scattered in the Geoplanidæ, become massed in front, so does the individuality of the brain become more and more pronounced. These sense-organs are of four kinds. The tentacles with eyes at their bases, found only in two South American forms. A paired sensory ridge forming a margin to the anterior part of the ventral surface in Geoplanidæ, and to the dorsal and ventral edges of the "cephalic plate" of Bipaliidæ. These ridges are innervated by the cutaneous nerve-plexus. Then the sensory pits which accompany these ridges, but which are supplied direct from the central nervous system. Lastly, the eyes. Of these there are two kinds. One, with the usual Turbellarian type of structure, has the rods directed away from the light, and the nerve entering in front and not, as in most other Invertebrates, from behind. This kind of eye occurs not only down both sides of the whole length of the body in the Geoplanidæ, but also on the dorsal and even the ventral surface. In the Bipaliidæ such eyes are concentrated at the margin and angles of the "cephalic plate." The other type of eye is one common to most Invertebrates, but hitherto unknown in Turbellaria. It consists of a pigment cap with a nerve perforating it behind, and entering the rod-cells, which face outwards towards the light. Such are the large paired eyes of the Rhynchodemidæ, and they are often imbedded in the nervous matter of the "brain."

The most novel and richly illustrated section of the anatomical part of von Graff's volume is, however, that in which the unexpected complexity and variety of the reproductive organs is discussed. This chapter is a most important addition to Turbellarian anatomy, and the results well repay the labour which has been spent on its preparation and illustration.

The next section, a short one, is devoted to the habits of land-planarians. Here, as in the other sections, the author has collected and given *in extenso* all the essentially important information that has been previously obtained. In this section, however, he adds little to the observations of Darwin, Moseley, Dendy, von Kennel and others. Land-planarians, though capable of withstanding considerable variations of temperature, are almost instantly killed by contact with dry objects, and by immersion in water, whether fresh or salt. The majority flourish best in dark, moist places. They are nocturnal, living by day under stones and tree-

trunks, under the sheaths of bananas, and on tree-ferns. Some are actually subterranean, and live on earth-worms. These are blind. But most land planarians are content with a diet of snails, woodlice and insects. *Rhynchodemus vejtdowskyi* is one of the few diurnal forms. It not only crawls about by daylight, but moves with such grace and rapidity that when von Graff saw it at Buitenzorg he mistook it at first for a Myriapod. A species of *Geoplana* has been found in some numbers creeping on the pavement of Melbourne in broad daylight.

The coloured plates, which show the appearance and bizarre markings of land-planarians, form quite a feature of von Graff's work. The ground colour is usually diversified by mottling or by brilliant longitudinal stripes. Bold transverse bars of colour are comparatively rare, but they occur in a small group of each of the two families, Bipaliidæ and Geoplanidæ. It is an extremely curious fact that all the barred species of the former family are confined to the islands of the Malay Archipelago; all those of the latter to the Chilian sub-region, with a single exception found in Brazil.

With reference to any supposed significance of these colours, von Graff suspends his opinion. Dendy, it is true, has shown that *Geoplana* produces an unpleasant taste on the tongue, and that fowls readily pecked at this planarian, but would not swallow it. A casual experiment of this kind is, however, not sufficient to justify the assertion that the colours of the land-planarians are of the "warning" category. The great difficulty is how to explain the prevalence of such brilliant colours and definite patterns in a group which is almost exclusively nocturnal. Yellow is the commonest colour, then orange, red, green, blue and violet. In young specimens, the pattern is more sharply defined, and the pigment (which is present both in large, richly branched connective-tissue cells and in the parenchymatous matrix) relatively more abundant than in the adult. No experiments appear to have been made to test whether land-planarians possess the power of colour-change. As with many other groups of animals upon which elaborate anatomical monographs have been written, the physiology of land-planarians is practically unknown.

The distribution of this group is very interesting, and is clearly illustrated by von Graff both by tables of every species and by a coloured map. To one of the main facts, their rarity north of the Equator and their abundance in the tropics, I have already adverted. Another interesting and suggestive discovery is the large proportion which occur on islands. More than half of the known species (201 out of 348) are purely insular, and each of almost all these (186) is limited to one island. As showing that this is only one of several indications of the local distribution of many species, von Graff points out that only five land-planarians occur in two geographical regions, only twenty in two subdivisions of the six regions, and but eighteen in two parts of the same region separated by an arm of the sea. The land-planarians afford a striking proof of the value of the Sclater-Wallace regions, which accordingly are adopted by the author.

The Oriental region is, perhaps, the richest, certainly the best characterised. Five-sixths of the family Bipaliidæ are confined to this region, and the remainder occur in Madagascar (most of the species being peculiar to this

island) and Japan. The land-planarians of the Australian and neotropical regions are alike in one striking feature. The family Geoplanidæ is practically divided between them. The neotropical members of the genus *Geoplana* include most of the flattened primitive ones, and also peculiar forms such as *Leimacopsis* and *Polycladus*. Von Graff goes so far as to share the opinion that this geoplanid fauna has arisen on a lost Antarctic continent, and has spread on the one hand to New Zealand and Australia, on the other to South America. The distribution of earthworms lends strong support to this view, as Mr. Beddard has shown.

The concluding section of the work is composed of full systematic descriptions of the families, genera and species. Von Graff makes five families: the Limacopsidæ, with two tentacles; the Cotyloplanidæ (an unnatural family), with suckers; the Geoplanidæ, with scattered eyes; the Bipaliidæ, with the eyes limited to the flattened "head"; and the Rhynchodemidæ, with a pair of large eyes. There are now nineteen genera, many of which are new.

This monograph will be of inestimable value to all naturalists interested in land-planarians, and the author is to be congratulated on having completed such a laborious task with unflinching accuracy. The lithographers and publishers deserve a special word of praise for the beautiful plates and printing which adorn this book.

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A SCIENTIFIC ENGINEER.

Papers on Mechanical and Physical Subjects. By Osborne Reynolds, F.R.S. Vol. i. Pp. xv + 416. (Cambridge: University Press, 1900.)

THE Cambridge University Press has during some years past contributed very largely to the progress of physical science by the issue of the collected works of great mathematicians and physicists. The volumes which contain the collected writings of Maxwell, Adams and Cayley form a rich storehouse of knowledge; and the efforts the Press has made to induce living writers, such as Kelvin, Stokes and Rayleigh, to edit their own papers for issue in a collected form deserve the gratitude of all students.

Among the latest of such reprints is the volume before us. Its author, Prof. Osborne Reynolds, has passed a busy life as a teacher in a great commercial and manufacturing city, and his collected papers testify to the breadth of his interests and the wide scope of his work.

The papers included in the present volume, some forty in number, were published between 1869 and 1882. They range over a great variety of subjects, from the tails of comets and the solar corona to problems connected with the steering of ships and the bursting of guns. In so varied a collection the relative importance of the different papers differs greatly, and yet all are interesting; and all have advanced the sum of human knowledge.

Indeed, on reading them, one cannot help regretting that the author's interests have been so widely diffused, and that he has not had the opportunity of concentrating himself on some one or other of the great engineering problems which await solution, applying to it his practical experience and insight and his mathematical skill.

An extract from the author's preface makes the cause of this clear. He writes:

"As affording some explanation of the absence of any connection between many of the subjects in this collection of papers, it may be pointed out that these subjects have not been determined by arbitrary selection, neither have they been the result of following up one line of research. They have for the most part been suggested by the discrepancies between the results obtained in definite mechanical arrangements, such as occur in some parts of the large field of practical mechanics, and the conclusions arrived at as to what those results should be for the same circumstances, by means of geometrical and physical analysis, as far as this analysis was developed at the time."

But to turn to the matter of the papers; it would take too long to attempt to analyse them all; and, indeed, the results of the most important are now classic, e.g. those on the refraction of sound, the action of a screw propeller, the steering of screw steamers, and the explanation of the radiometer.

The two papers on the refraction of sound are numbered 16 and 22. Stokes had, seventeen years before the date of the first of these papers, suggested the reason why sounds are heard less distinctly against the wind than with it. It is due to the fact that the velocity of the wind rises as we ascend; hence when a sound-wave is travelling against the wind, the wave-velocity is less in the upper portion of the wave than in the lower; thus the wave-front is bent upwards, and the sound passes over the head of the observer. The same notion occurred to Reynolds; he verified it by direct experiment, and pointed out, moreover, that in ordinary conditions of the atmosphere the temperature falls as we ascend; hence from this cause also the wave-velocity is reduced, and the path of the sound is no longer straight, but curved, with the convexity of the curve turned downwards. If, however, it should happen that the air is warmer above than it is below, the reverse will be the case—the sound-waves will be bent downwards—the sound will thus be audible at a greater distance than previously.

The papers on the action of the screw propeller form an interesting series. The racing of a screw is proved to be due to the admission of air to the screw; this, it is shown, interferes with the power of the screw to obtain water, and also reduces the resistance which would otherwise be offered by the water the screw would get. For consider a vertical plate, totally immersed in water, which is being pushed forward; its speed may be such that the water behind cannot remain continuously in contact with it. A vacuum will tend to form behind the plate; the limiting velocity at which this takes place will depend on the pressure in the water behind the plate; if no air can reach the plate, this pressure will be the atmospheric pressure, together with that due to the depth of water above the plate; if air can reach the space behind the plate, the limiting velocity will depend only on the pressure due to the water, and will be much less than in the first case. The blades of the propeller act like the plate; a stationary screw will be most effective in propelling water when it is turning so fast that a vacuum is just formed behind its floats, and the rate at which the water is driven past depends on the water pressure just close to the floats; if air can reach the floats,